OPTIMUM CONDITIONS FOR SUCROSE PRODUCTION USING ULTRASONIC TREATMENT

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I declare that this thesis entitled “Optimum Conditions for Sucrose Production Using Ultrasonic Treatment” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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To my beloved father and mother

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ABSTRACT

The purpose of this study is to determine the optimum conditions for sucrose production using ultrasonic treatment. The raw material used in this study is coconut sugar. With the increasing number of diabetics in the world, the demands for natural, organic, non-calorific and cheap sugar are on the rise. Thus, the sucrose obtained from this coconut sugar can be used to produce fructooligosaccharides (FOS) from the reaction with fructosyl transferase (FTase) enzyme. FOS is non-digestible carbohydrates, exhibits sweetness levels between 30 to 50 per cent of sugar, low caloric value and prebiotic to stimulate the bifidobacteria growth in human colon. As such, FOS can replace the common table sugar and also artificial sweeteners that are supposedly harmful to human. Ultrasonic technology can also be promoted for the usage in the food processing industry as an alternative method to conventional heat treatment that is degradable to food quality and nutrients. The coconut sugar concentrations that were used in this study were 40, 60 and 80 % w/v, diluted in pH 5.5 acetate buffer solution. Ultrasonic frequencies of 25, 68 and 132 kHz were used to treat these coconut sugar concentrations for 5 hours with the samples being analyzed every 30 minutes. The determination of sucrose composition in the treated coconut sugar was by dinitrosalicylic acid (DNS) methods, with measurement of absorbance at 580 nm using UV-Visible Spectrophotometer. It was observed that the sucrose compositions in the coconut sugar increased with time, with occasional drops during treatment. The highest amount of sucrose was found to be in 80 % w/v coconut sugar concentration at 68 kHz ultrasonic treatment. However, the highest percentage of sucrose increased was found in 60 % w/v coconut sugar concentration. Hence, it can be concluded that the highest sucrose production was 68.63% of the original amount at conditions of 60 % w/v coconut sugar concentration and treated at 68 kHz ultrasonic treatment.

ABSTRAK

Kajian ini bertujuan untuk mengenalpasti keadaan optima untuk produksi sukrosa dengan mengunakan kaedah ultrasonik. Bahan yang digunakan dalam kajian ini ialah gula kelapa. Dengan pertambahan bilangan penghidap diabetes dalam dunia, permintaan untuk gula asli, organik, tiada kalori and murah semakin bertambah. Oleh itu, sukrosa yang didapati daripada gula kelapa boleh digunakan untuk menghasilkan fruktooligosakarida (FOS) dengan tindakbalas enzim *fructosyl transferase* (FTase). FOS ialah sejenis karbohidrat yang tidak boleh dihadam, tahap kemanisan di antara 30 hingga 50 peratus dari gula biasa, nilai kalori rendah dan prebiotik untuk pertumbuhan bifidobakteria dalam usus manusia. Dengan itu, FOS dapat menggantikan gula biasa dan juga gula sintetik yang dikatakan mendatangkan bahaya kepada manusia. Teknologi ultrasonik boleh digunakan dalam industri pembuatan makanan sebagai kaedah alternatif kepada penggunaan konvensional haba yang boleh memusnahkan kualiti dan nutrient makanan. Kepekatan gula kelapa yang digunakan dalam kajian ini ialah 40, 60 and 80 % b/i, dilarutkan dalam larutan penampan asetik pH 5.5. Frekuensi ultrasonik 25, 68 and 132 kHz digunakan untuk merawat gula kelapa selama 5 jam, dengan analisis sampel setiap 30 minit. Kandungan sukrosa dalam gula kelapa yang dirawat, diuji dengan menggunakan kaedah asid dinitrosalisilik (DNS), seterusnya menggunakan *UV-Visible Spectrophotometer* untuk menentukan bacaan penyerapan pada 580nm. Data yang diperoleh menunjukkan kandungan sukrosa meningkat, walaupun terdapat beberapa kekurangan semasa eksperimen dijalankan. Kandungan sukrosa yang tinggi terdapat dalam kepekatan gula kelapa 80 % b/i pada frekuensi ultrasonik 68 kHz. Walau bagaimanapun, peratusan peningkatan sukrosa yang tertinggi didapati dalam kepekatan gula kelapa 60 % b/i. Peratus peningkatan penghasilan sukrosa adalah pada kepekatan gula kelapa 60 % b/i dan frekuensi ultrasonik 68 kHz, iaitu sebanyak 68.63%.

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LIST OF ABBREVIATIONS/SYMBOLS

b/i	-	berat per isipadu
DNS	-	dinitrosalicylic acid
USD	-	United States Dollar\
g	-	gram
g/L	-	gram per liter
kcal/g	-	kilocalorie per gram
kHz	-	kilohertz
L	-	liter
M	-	Molar
ml	-	mililiter
mmol/l	-	milimol per liter
N	-	normality
nm	-	nanometer
°C	-	degree Celsius
%	-	percent
% w/v	-	percent weight over volume
µL	-	microliter

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CHAPTER 1

INTRODUCTION

1.1 Background of Research

The word sugar originates from the Arabian word *assukkar* (Ponce-Lee *et al*., 2004). As stated by Mohammad *et al*. (2005), sugar act as sweetening agents, gel or paste-forming and thickening agents, stabilizers and also precursors for aroma and colouring substances generated within the food by a series of reactions and during handling and processing. Sugar, or also called as sucrose, occurs naturally in every fruit and vegetable (Mundt and Wedzicha, 2003). The common, white table sugar crystal that is in everyday diet is made from sugar cane and sugar beet.

Other types of sugars that are gaining reputation in the food and beverages industries are alternative sweeteners such as high fructose corn syrup (HFCS), corn syrup, maple syrup, honey, malt sugar, brown sugar, powdered sugar and so on. However, few studies have shown that these sweeteners could be harmful to human health, for example the sweeteners are sweeter and higher calorie than common table sugar. Synthetic sweeteners are also being introduced into these industries as these sweeteners have absolutely no calories. Dietitians and health practitioners alleged that the sweeteners can cause cancer to human as these types of sweeteners are

chemically made. These claims and allegations could not be proven true or false as research and studies are not done extensively and on human (National Cancer Institute, 2008).

Nevertheless, to be on a safer side, health-conscious consumers are looking for another type of sweetener that is organic, natural and most important of all, safe. One particular sugar that is in this study is the coconut sugar which is crude, dark brown color and in solid form (De Leon and Dolores, 1996). Previously, coconut sugar is not well-known in the world as it is typically produced traditionally and in small scale, mostly in rural areas. Nowadays, Philippines, Indonesia and Thailand have emerged to be the biggest producer of coconut sugar in the world. This success is due to the few studies which showed that coconut sugar has many benefits. As such, other products made from the coconut sugar also cropped up; include beauty products such as skin care, soap, lotions and others.

Coconut sugar contains 80% sugar, essential vitamins and amino acids, and macro and micronutrients (Punchihewa and Arancon, 1996). The main sugars are glucose, fructose and sucrose. It is less sweet than table sugar, thus has lower calorie. It is also classified as a low gylcemic index (GI) food, with GI of 35, which means that the blood glucose level does not rise rapidly and suddenly after consumption (Philippines Coconut Authority). These great properties are beneficial especially for diabetics who need to control their blood sugar level. What is more is that this sugar is natural and does not contain any additive chemicals.

Coconut sugar is made from the sap of the coconut tree. The sap is sweet and watery, derived from the bud or flower of the coconut tree. The sap is boiled at high temperature and long duration time, with constant stirring. The juice will turn into viscous liquid. When the liquid become viscous, it is poured into moulds and the liquid will solidified to form the hard-rock coconut sugar (Apriyantono *et al*., 2002).

Conventional treatment, which is the heat treatment, is popular for so many years in the processing and preservation industry. Heat treatment uses very high temperature to inactivate and kill microorganisms in food products. This inadvertently degrades and spoils the quality and nutrients in the food products. At the present time, new technologies, such as microwave, ultraviolet irradiation, high pressure, ultrasonic and so on, emerged to counteract this shortcoming (Ashokkumar *et al*., 2008). These technologies, which do not use heat, can be used alone or together with heat treatment at lower temperature to give more effective treatment.

Ultrasonic treatment is used in this study to treat the coconut sugar. Ultrasonic waves generate vibrations through liquid medium and at high frequency, cavitations will occur. Cavitations is the making and breaking of the microscopic bubbles. These bubbles form and collapse inwardly and violently, generating mechanical forces (Cameron *et al*., 2008). These forces replace the heat used in heat treatment.

Ultrasonic treatment is still a new technology in the food industry. It is a promising technology as it has many advantages. Ultrasonic treatment has advantage compare to the conventional treatment, where the treatment can be done at much lower temperature and absolutely no heating is required. This can also kill pathogens and microorganisms. Thus, it does not degrade the quality and nutrients of the food products, maintaining its original and fresh-like quality (Cameron *et al*., 2008).

The aim of this research is to study the effects of varieties of ultrasonic frequencies on the treatment of three different concentrations of coconut sugar. The sucrose compositions are determined over time in order to determine the effect of the ultrasonic treatment. The conditions where the highest sucrose composition presents are identified.

1.2 Problem Statement

Over the years, the number of people suffering from diabetes is ever increasing. According to American Diabetes Association, diabetes is a disease where the body does not produce or properly use insulin, causing the blood sugar level to increase drastically. Insulin is a hormone that is needed to move sugar, starches and other food, which is converted into energy needed for daily life, into the cells. Diabetics are not allowed to consume high calories foods, such as fatty foods, high carbohydrates and sugar, and have a proper consumption of the three main nutrients, such as proteins, carbohydrates and fats (Hagura, 2000).

Common table sugar is mostly made of sugar cane and sugar beet. It is thought to absorb quickly, thus rapidly increasing the level of blood sugars (Khazrai, 2006). Based on Food and Nutrition Research Institute (FNRI) and Department Of Science Technology (DOST) in Philippines (2007), the glycemic index (GI) of cane sugar is 50, which is quite high. Glycemic index, according to a scientist from Food and Nutrition Research Institute, is the glucose response of an individual from food relative to a standard glucose solution. Cane sugar is also sweeter than any other sugar and has high calorie. Thus, common table sugar is not suitable for consumption of a diabetic.

Sucrose is a raw material for a compound name fructooligosaccharides (FOS). FOS is beneficial for diabetics, colon disease patients and consumers who want a healthy diet. FOS has properties such as low in sweetness level, low in calories, rich in fibers and as a prebiotic to promote bifidobacteria growth in human colon. Nevertheless, FOS is sold at higher price. This is because the production of FOS requires a lot of work, from the making of sugar, extracting sucrose and to reaction with fructosyl transferase (FTase) enzyme to form FOS. Moreover, production is little as not much study is done to promote and commercialized the use of FOS as an alternative sweetener.

Besides, alternative sweeteners such as high fructose corn syrup, corn syrup and malt sugar, are replacing sucrose as sweetener products in the food and beverages industry. These sweeteners contain one or more of sucrose and the other saccharides such as glucose, fructose, galactose and lactose. Few studies had been done to determine the effect of these other saccharides, alone and combine. The results were not as encouraging as using sucrose as the sweetener. Moreover, some saccharides are little and not obtained naturally.

Synthetic sugars or artificial sweeteners are not natural as they are made from chemical processes and have no calories, which also mean no nutritive values (Sardesai and Waldshan, 1991). Synthetic sugars contain active ingredients that have strong biological effects and the safety is not always assured in all users (Food and Drug Administration, 2008). Although there are no prove to determine the safety of their usage, some people are skeptic about the usage as there are many claims, one leading to cancer and also death. Some synthetic sugars could cause diarrhea while others contain more fat and calories in food products, while the most serious effect is cancer (American Diabetes Association).

1.3 Objectives

The objectives of this study are:

i) To determine the effect and optimal value of ultrasonic frequencies to the sucrose composition during ultrasonic treatment of coconut sugar.
ii) To determine the effect and optimal value of coconut sugar concentration during ultrasonic treatment of coconut sugar.
iii) To determine the effect of exposure time during ultrasonic treatment to the sucrose compositions.

1.4 Scope of Study

The scopes of this study are:

i) The material that is used for the treatment of coconut sugar is the food grade coconut sugar.
ii) The treatment of coconut sugar using ultrasonic treatment with ultrasonic frequencies of 25, 68 and 132 kHz.
iii) The temperature of treatment is set at 25 °C.
iv) Coconut sugar at concentrations of 40, 60 and 80 % w/v are used.
v) The pH set for this treatment is pH 5.5 acetate buffer.
vi) The exposure time for the treatment of coconut sugar is 300 minutes with sampling at time interval of 30 minutes.
vii) The concentration of sucrose in coconut sugar is analyzed by using dinitrosalicylic acid (DNS) method with measurement using UV-Visible Spectrometer with absorbance at 580nm.

1.5 Significant of Study

Coconut sugar has many potential benefits that are yet to be discovered. Coconut sugar is totally natural, contain nutrient, free from additives and artificial flavouring. As such, coconut sugar can be used to replace the common sweeteners and artificial sweeteners, reduce the calories intake and can also be used by diabetes patients. The natural property of coconut sugar will also make the sugar the first choice to consume rather than consuming chemically-made sugars which are surrounded by myths of causing danger to health.

Coconut sugar contains sucrose which is the raw material for fructooligosaccharides (FOS). This compound is important for diabetics and colon disease patients. The importance for diabetics is that FOS does not increase the body weight of the person, thus proving that FOS is low in calorie, low in sweetness and suitable for diabetics (Gudiel and Goni, 2002). FOS increase potentially beneficial fecal bacteria, including bifidobacteria, which is vital to fight colon disease (Euler *et al*., 2005). With these properties, coconut sugar could provide a lot of benefits to diabetics and consumers who want to have a healthy and controlled diet.

Coconut sugar is usually produced traditionally. This contributes to the coconut sugar being sold at a low price. Sucrose can be optimized from the coconut sugar. Sucrose can be obtained and used to produce FOS. Therefore, FOS can be sold commercially and at a much cheaper price than usually sold.

Coconut sugar contains nutrients and it is much better than common table sugar and synthetic sugars in many ways. The glycemic index of coconut sugar is 35 (Philippines Coconut Authority, 2004/5), which is much lower then cane sugar, enables coconut sugar to be a substitute sweetener for diabetics. It is also less sweet than cane sugar. Coconut sugar is purely organic, prepared directly from coconut sap and contains no artificial colouring and flavouring. It is also much cheaper than the synthetic sugars sold over the counter. The benefits should be studied more extensively to recognize its potential in replacing unhealthy common table sugar, high fructose corn syrup and other sugars in the food processing industry.

This would in a way, promote the benefit of planting coconut trees and add values to the coconut plantations. More plantations will be opened, thus creating more jobs for the locals. Coconut farmers can also expand their businesses and venture into the coconut sugar market, which will bring extra income.